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ATSUKO COMPUTING
INTERNATIONAL

ACI-021185-FR

February 11, 1985

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Attention: AP29-F

Subject: Final Report -- "Digital Processing of Mesoscale Analysis
and Space Sensor Data"

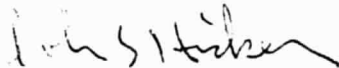
Dear Sir:

Atsuko Computing International (ACI) is pleased to submit this Final Report for Contract NAS8-35917, entitled "Digital Processing of Mesoscale Analysis and Space Sensor Data", as an Enclosure to this letter.

If you have any questions concerning this Final Report, please contact me at (205) 533-7590 (ACI's Office) or 453-0400 (NASA work area).

Sincerely,

ATSUKO COMPUTING INTERNATIONAL



John S. Hickey
Principal Investigator

JSH/jh

Enclosure: Final Report

Copies of Enclosure to:	AS24D	(5)
	AT01	(1)
	EM13a-15	(1)
	ED44/Laura MacLean	(1) + repro
	NASA Scientific & Technical Information Facility	(1) + repro

(NASA-CR-171429) DIGITAL PROCESSING OF
MESOSCALE ANALYSIS AND SPACE SENSOR DATA
Final Report (Atsuko Computing
International) 17 FEB 85 02/ME AD1 CSCL 05B

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ATSUKO COMPUTING
INTERNATIONAL

ACI-021185-FR

DIGITAL PROCESSING OF MESOSCALE ANALYSIS AND SPACE SENSOR DATA

FINAL REPORT

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

Attention:

AP29-F

Under Contract:

NAS8-35917

Prepared by:

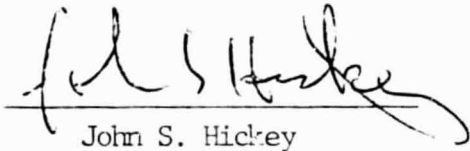
John S. Hickey
Shogo Karitani

February 11, 1985

PREFACE

This is the Final Report prepared by Atsuko Computing International (ACI), under Contract NAS8-35917, entitled "Digital Processing of Mesoscale Analysis and Space Sensor Data", for the Atmospheric Sciences Division of the Marshall Space Flight Center. The NASA technical monitor for this contract is Ms. Laura MacLean/ED44.

Prepared by:



John S. Hickey



Shogo Karitani

ABSTRACT

This report describes the Mesoscale Analysis and Space Sensor (MASS) Data Management and Analysis System developed by Atsuko Computing International (ACI) on the Research Computer System within the Atmospheric Sciences Division (ASD) of the Systems Dynamics Laboratory at NASA's Marshall Space Flight Center (MSFC).

The MASS Data Base Management and Analysis System has been successfully implemented on the ASD Research Computer System which now provides over 20 atmospheric scientists with a wide range of capabilities for processing and displaying large volumes of conventional and satellite derived meteorological data.

The ASD Research Computer System consists of three primary computers (HP-1000F, Harris/6, and Perkin-Elmer 3250), each of which performs a specific function according to its unique capabilities. The scientists may access any of the three computers from the convenience of their office or remote location using an Apple III microcomputer "workstation".

The primary focus of this Final Report is to provide a description of the overall tasks performed by ACI concerning the software, data base management and display capabilities of the ASD Research Computer System in terms of providing the scientists with a very effective interactive research tool for the Digital Processing of Mesoscale Analysis and Space Sensor Data.

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1.0 INTRODUCTION

Atsuko Computing International (ACI) is pleased to submit this Final Report under Contract NAS8-35917, entitled "Digital Processing of Mesoscale Analysis and Space Sensor Data", to the Atmospheric Sciences Division of the Systems Dynamics Laboratory at the Marshall Space Flight Center.

The Atmospheric Sciences Division (ASD) is currently involved in the interactive information processing for the Mesoscale Analysis and Space Sensor (MASS) program. Specifically, the ASD is involved with the development and implementation of new space-borne remote sensing technology to observe and measure mesoscale atmospheric processes. These space measurements and conventional observational data are being processed together to gain an improved understanding of the mesoscale structure and the dynamical evolution of the atmosphere relative to cloud development and precipitation processes.

To satisfy the ASD's vast data processing requirements, a Research Computer System consisting of three primary computers (see Figure 1-2, Appendix A) was developed which provides over 20 scientists with a wide range of capabilities for processing and displaying interactively large volumes of remote sensing data.

ACI personnel have been directly involved in the design, development, and integration of both software and hardware for the MASS Research Computer System. ACI's major effort has been to develop a MASS Data Base Management and Analysis System on the HP-1000F computer and then to extend these capabilities by integration with the Harris/6 and Perkin-Elmer computers using the MSFC's Apple III microcomputer workstations.

The primary objectives of this research study performed by ACI were to enhance the existing MASS software/hardware capabilities and to extend the data base management. A sequence of tasks performed by ACI under this contract to accomplish these objectives follows:

- o -- Developed and provided the necessary computer codes to provide video, graphics, and character display of MASS program data using MSFC's Apple III micrographics/imaging "workstations" to communicate with NASA's Harris/6 and Perkin-Elmer 3250 computers.
- o -- Developed and provided the necessary computer codes to transfer the four basic MASS data types (Image, Soundings, Grids, Single Level) from the HP-1000F computer to the Harris/6 and Perkin-Elmer 3250 computer.
- o -- Extended the data base management and processing software codes on the HP-1000F computer to analyze LLP lightning data, TVA and NCC rainfall data, MDR digital radar data, and VAS multispectral imagery data.

- o -- Provided system software updates and applications software computer code improvements for the HP-1000F and MASS data analysis system as needed.
- o -- Provided software computer code updates and user guidance as to the operation and capabilities developed for the atmospheric scientists participating in the MSFC's MASS program.
- o -- Provided computer code description and MASS Research Computer System capabilities for technical paper entitled "Interactive Information Processing for NASA's Mesoscale Analysis and Space Sensor Program", (see Appendix A).

1.1 OVERVIEW

The remainder of this report documents and summarizes the results of the entire contract work, including recommendations and conclusions based on the experience and results obtained. Appendix A provides principles, procedures, and methods of application that would be generally applicable to the utilization of the results of the research study.

2.0 OVERALL RESULTS

During this research study entitled "Digital Processing of Mesoscale Analysis and Space Sensor Data", ACI has performed all tasks as defined within the contract and details the results of each task in the following subsections.

2.1 DEVELOP AND INTEGRATE GRAPHICS/IMAGING CAPABILITIES

ACI has developed the capability to provide video graphics and character display of MASS data utilizing the Apple III micrographics/imaging terminal "workstations" and provided for the integration of the Apple III terminals with the Harris/6 and Perkin-Elmer 3250 computers.

2.2 DEVELOP AND INTEGRATE DATA BASE MANAGEMENT

ACI has developed the capability to transfer the existing four MASS data types (Soundings, Grids, Single Level, Images) from the HP-1000F computer to the Harris/6 and Perkin-Elmer 3250 computers.

2.3 EXTEND DATA BASE MANAGEMENT

ACI has provided the capability to process on the HP-1000F computer (using the AVE80 code) additional data type (LLP lightning data, TVA and NCC rainfall data, MDR digital radar data, and VAS multispectral imagery data). The data base management software has been extended to process the above additional data types and to make available to the scientists by storing on the newly installed HP 400mb disc drive. Currently only a limited number of LLP lightning data sets and TVA/NCC rainfall data resides online, but additional data sets can continue to be added (including MDR digital radar data and VAS multispectral imagery) as data becomes available and disc space remains sufficient.

2.4 ENHANCE APPLICATION SOFTWARE AND UPDATE SYSTEM SOFTWARE

ACI has provided application software enhancements and modifications for the HP-1000F (AVE80 series code) and MASS data analysis system as needed. In addition, all system level software updates (including HP-1000 Operating Systems and Systems Generations) were performed as conditions dictated.

2.5 PROVIDE USER UPDATE ASSISTANCE AND GUIDANCE

ACI has assisted the atmospheric scientists participating in the MSFC's MASS program in providing software and user guidance as to the operations and capabilities developed by ACI on the MASS Research Computer System.

2.6 PROVIDE SUMMARY REPORTS

ACI has provided summary reports describing the computer codes developed and system improvements/capabilities for the MASS computer system. As an appendix to this report (Appendix A), a technical paper is provided, which was co-authored by ACI and others, which describes in detail the overall software/hardware capabilities of the MASS Research Computer System and specifically the data base management, analysis/display software and the Apple II "workstations".

3.0 CONCLUSIONS & RECOMMENDATIONS

In summary, the MASS system/software developed by ACI for the ASD Research Computer System provides the research scientist with the following capabilities:

- o -- An extensive Data Base Management package to convert various experiment data into standard formats for accessing by the general purpose plotting and data analysis packages.
- o -- An Analysis and Display package (AVE80) to graphically display and analyze large volumes of conventional and satellite derived meteorological data.
- o -- An interactive imaging/color graphics capability utilizing Apple III "workstations" integrated into the ASD Research Computer System.
- o -- Local and remote smart-terminal capability which provides color video, graphics, and character display of the various data.

To meet the growing requirements of the MASS program and the scientists utilizing the ASD Research Computer System, the system must continue to be upgraded and enhanced. To enhance the current capabilities of the system to better meet the needs of the scientists ACI recommends the following:

- o -- Develop a "patch panel" communications network between the ASD three computer systems and APPLE III workstations.
- o -- Extend the current data base management and archiving software.
- o -- Upgrade the AVE80 Series HP-1000 software from Graphics 1000 to Graphic II.
- o -- Extend the APPLE III "workstation" capabilities (integrated with the Harris/6 and Perkin-Elmer) to enhance both imaging and graphics.
- o -- Develop a "3-D" graphics capability for the AVE80 Series code utilizing the Advanced Graphics Package software.
- o -- Utilize the HP-1000 RTE-VI Command Interpreter to replace the existing FRCR, and restructure data file naming conventions.

APPENDIX A

This appendix contains a technical paper entitled "Interactive Information Processing for NASA's Mesoscale Analysis and Space Sensor Program". This paper was authored by ACI, New Technology, MSFC, and the Universities Space Research Association, and presented at the AMS Conference, January, 1985 (Los Angeles, CA).

This appendix is included because it gives a very good description of the ASD Research Computer System (both descriptive and graphic) and describes in detail the data base management, applications software, (AVE80 code), and the APPLE III "workstation", which ACI was responsible under this contract.

INTERACTIVE INFORMATION PROCESSING FOR
NASA'S MESOSCALE ANALYSIS AND SPACE SENSOR PROGRAM

Karen G. Parker
New Technology, Inc.

Laura MacLean Norman Reavis Gregory Wilson
NASA/Marshall Space Flight Center

John S. Hickey Michael Dickerson Shogo Karitani
Atsuko Computing International

David Keller
Universities Space Research Association

Atmospheric Sciences Division/ED44
Marshall Space Flight Center, AL 35812

1. PROGRAM OVERVIEW AND DATA PROCESSING
REQUIREMENTS

The Atmospheric Sciences Division (ASD) of the Systems Dynamics Laboratory at NASA's Marshall Space Flight Center (MSFC) is currently involved in interactive information processing for the Mesoscale Analysis and Space Sensor (MASS) program. Specifically, the ASD is engaged in the development and implementation of new space-borne remote sensing technology to observe and measure mesoscale atmospheric processes. These space measurements and conventional observational data are being processed together to gain an improved understanding of the mesoscale structure and the dynamical evolution of the atmosphere relative to cloud development and precipitation processes. Figure 1-1 provides an overview of this ASD research and development effort.

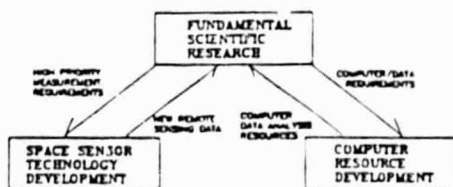


Figure 1-1. ASD Research and Development Activities

To satisfy its vast data processing requirements, the ASD has developed a Research Computer System consisting of three primary computer systems (as shown in Figure 1-2) which provides over 20 scientists with a wide range of capabilities for processing and displaying large volumes of remote sensing data. Each of the computers performs a specific function according to its unique capabilities:

- Hewlett-Packard (HP-1000F) is utilized for management of large volumes of conventional and satellite derived meteorological data, data analysis and graphical display, and general-purpose computing.
- Harris/6 Man Computer Interactive Data Access System (McIDAS) is connected to the IBM McIDAS system at the University of Wisconsin thus allowing for convenient access and analysis of real-time data, satellite and conventional research data base and providing for graphical display/animation of space image data.
- Perkin-Elmer (P-E 3250) is utilized for numerical modeling and large number crunching tasks and has direct Remote Job Entry (RJE) access to a NASA Class VI computer (Cyber 205 located at Goddard Space Flight Center).

Scientists may access any of the three minicomputers from the convenience of their office or remote location using an Apple III microcomputer workstation.

The primary focus of this paper is to convey a description of the overall architecture, software, data management and display capabilities of the ASD Research Computer System in terms of the manner in which it provides the scientists with a very effective interactive research tool for the Mesoscale Analysis and Space Sensor program information processing.

2. DATA BASE MANAGEMENT CONCEPTS

As stated previously, each of the three minicomputers performs a specific function suited to its characteristics. Although the HP-1000F, Harris/6 and P-E systems are not directly connected to each other, it is mandatory that data move easily through the entire system in order to accomplish the required research. Figure 2-1

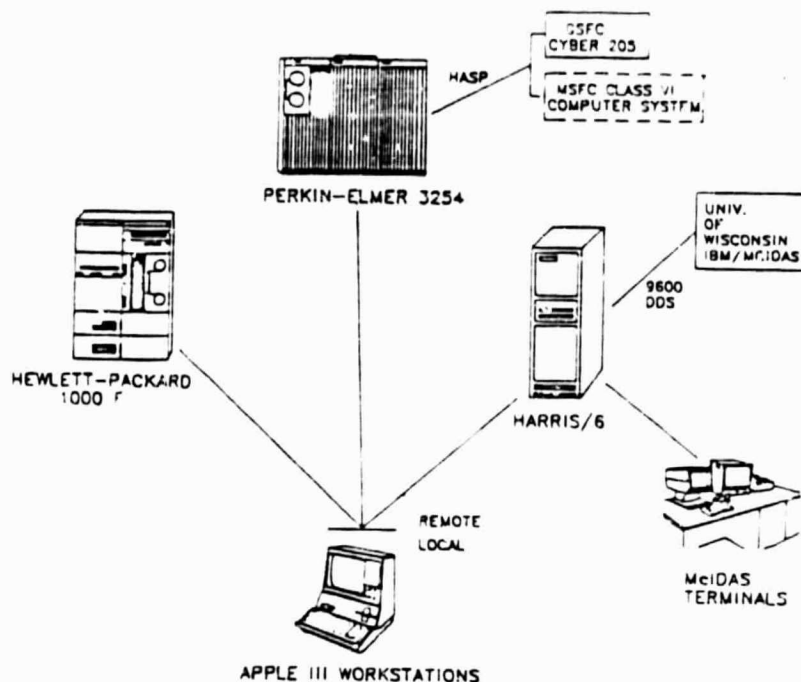


Figure 1-2. ASD Research Computer System

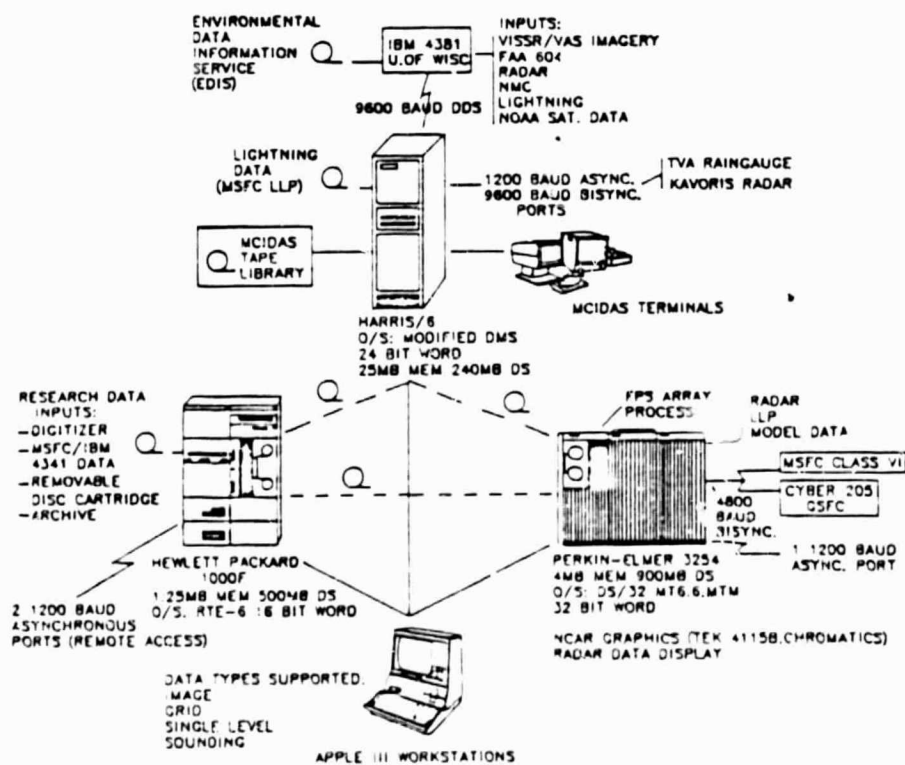


Figure 2-1. ASD System Data Flow Diagram

depicts overall data flow throughout the ASD system.

A typical example is to run a numerical model on the P-E using a data file acquired from the University of Wisconsin-Madison McIDAS via the Harris/McIDAS system, then transfer results of the model to the Harris via magnetic tape media for visual inspection or animation by the scientist using McIDAS.

The HP-1000F data base management software converts various meteorological experiment data into a standard format, thus making the data readily accessible to the analysis and display software (AVE80) and other general purpose plotting and analysis packages.

The four specific data types currently processed utilizing the data base management software are listed below and shown in Figure 2-2:

- 1) Soundings (Rawinsonde/Satellite)
- 2) Single Level (Surface, Cloud Winds, LLP, Precipitation, etc.)
- 3) Grids (from 1 and 2 above)
- 4) Image (Satellite, Radar)

All data sets are initially converted into a "standard" format and a "random access" disk file created and named according to a defined data file naming convention. The data is stored on the HP-7933 400 MB disk which has been structured to provide simple file management. Each data set type is assigned to a specific logical unit:

- 1) LU#40 -- 200 MB Image Data
- 2) LU#41 -- 100 MB Grid Data
- 3) LU#42 -- 50 MB Single Level
- 4) LU#43 -- 50 MB Soundings

The AVE80 analysis and display software expects the specific data types to exist on the assigned disk, along with a documentation file which describes the data base (number of times, stations, parameters, etc.) and a latitude/longitude file which provides the information for graphically plotting the station location, thus allowing for faster access while minimizing data housekeeping/archiving functions.

The four data types each have a dedicated "directory file" that contains the file names and parameter information for indexing into the "random access" data base. The number of stations, time periods, and data parameters are all provided in the directory file. The directory contains all data sets currently existing "on-line" or "archived". Only the frequently accessed data files are kept "on-line" for processing interactively by the analysis and display software.

In summary, the HP-1000F data base management provides numerous utility programs which provide for the following:

- Convert/create random access data base
- Create/update directory file
- Create documentation file
- Create latitude/longitude file
- Archive/restore data base

The Harris/6 offers the scientist a visual means of studying satellite, radar, or conventional data in an integrated manner. All of the data that comes into the McIDAS system can be put into one of three basic forms: images, grids, and 'Station Data Set' (SDS) files. McIDAS images and grids are rather straight-forward, two-dimensional data structures. The SDS structure is one in which there are any number of measurements made at one location at a given time. A typical example is a set of surface reporting stations which records temperature, wind direction and speed,

PROJECT DATA SETS

1. AVE/AVESS
2. AVE/SESAME
3. AVE/VAS
4. OTHER

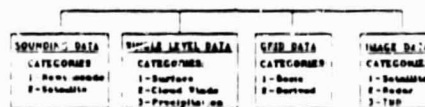


Figure 2-2. Data Base Management Software Data Types

pressure reading, cloud cover, and several other parameters each hour, all associated with one location at the same time (Figure 2-3a). Nearly any non-continuous data types can be put into this format, with the beneficial result that it can be plotted, or contoured (via the grid structure) with the same software program as shown in Figure 2-3d.

Conventional balloon, surface, satellite temperature and moisture soundings, (Figure 2-3c) and lightning strokes are examples of data that are put into SDS files. Radar data has been put into both the image and the grid format. Standard objective analysis software routines transform SDS data to the grid structure, usually for the contour drawing routine, but also for other research applications. The grids can then be put into an image format for display. Transformations in the reverse direction from the image structure to the other structures is usually done with a specialized research goal in mind, and algorithms are dependent upon the specific goal.

Although the P-E is primarily used for numerically-intensive processing, some file maintain data types such as image and grid data. Work is currently underway to implement a data management method of handling these files using format similar to that of the HP to facilitate transportability between machines.

3. COMPUTER SYSTEM HARDWARE/SOFTWARE/COMMUNICATION

By offering data management and display as well as numerical modeling/number crunching capabilities, the ASD Research Computer System serves as a very useful interactive tool for the scientists. Brief specifications of each of the three computers in the ASD system are:

- HP-1000F System (16-bit word) consists of 1.25 MB of main memory, 575 MB disk storage and operates under RTE-VI with session monitor and FORTRAN 66 compiler.
- Harris/6 System (24-bit word) consists of 0.25 MB of main memory, 320 MB disk storage, and operates under modified DMS.
- P-E 3250 System (32-bit word) consists of 8 MB of interleaved main memory, 900 MB disk storage and operates under OS/32 revision 4.2 with Multi-Terminal Monitor (MTM) and FORTRAN compilers D, O, and Z. A Floating Point Systems (FPS) AP-120B array processor is also attached to the P-E for off loading compute-bound jobs from the CPU.

Detailed hardware configurations are shown in Figures 3-1, 3-2, and 3-3.

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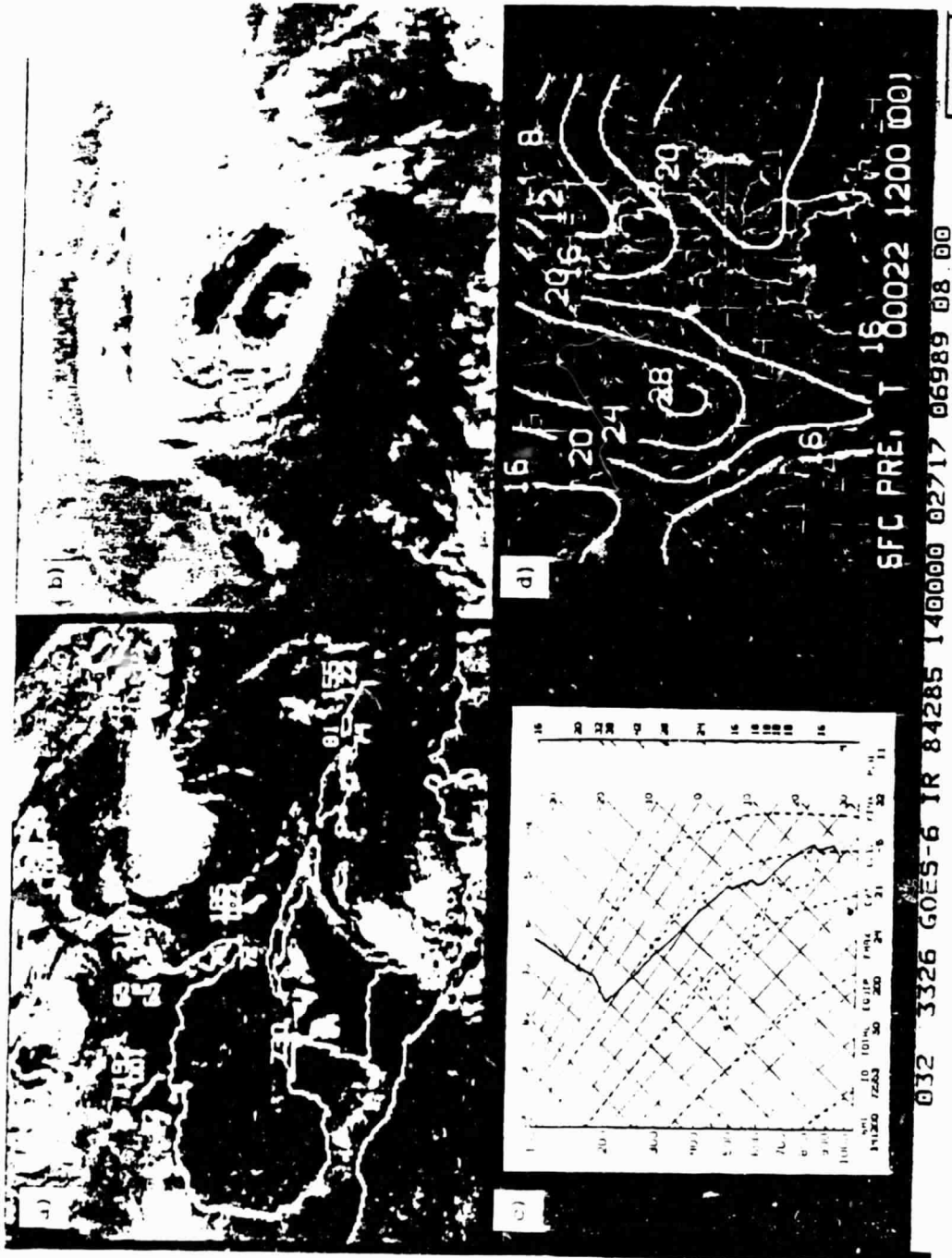


Figure 2-3. McIDAS Capabilities

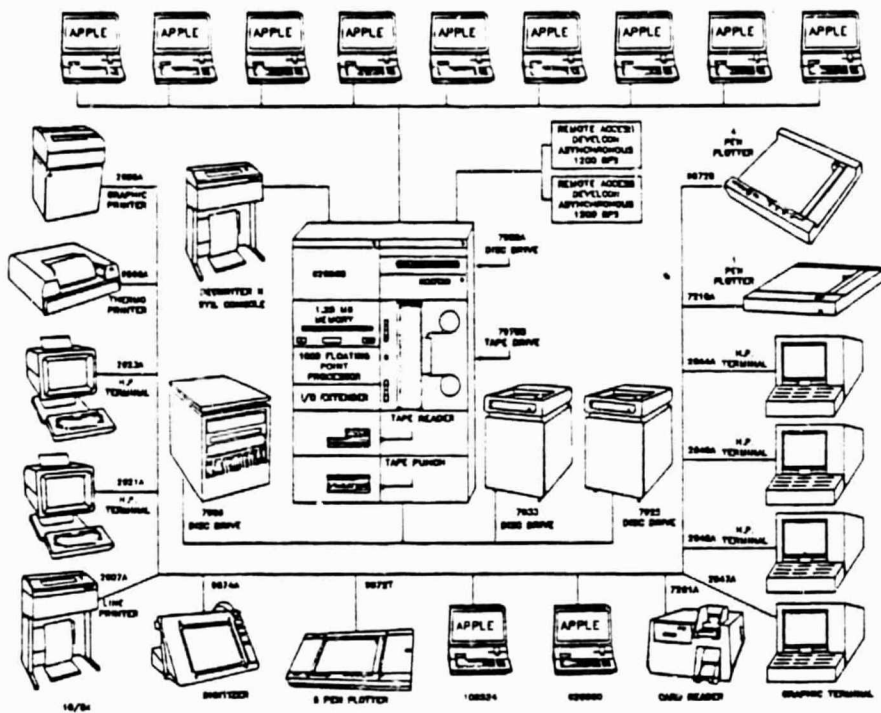


Figure 3-1. Hewlett Packard 1000F Computer System

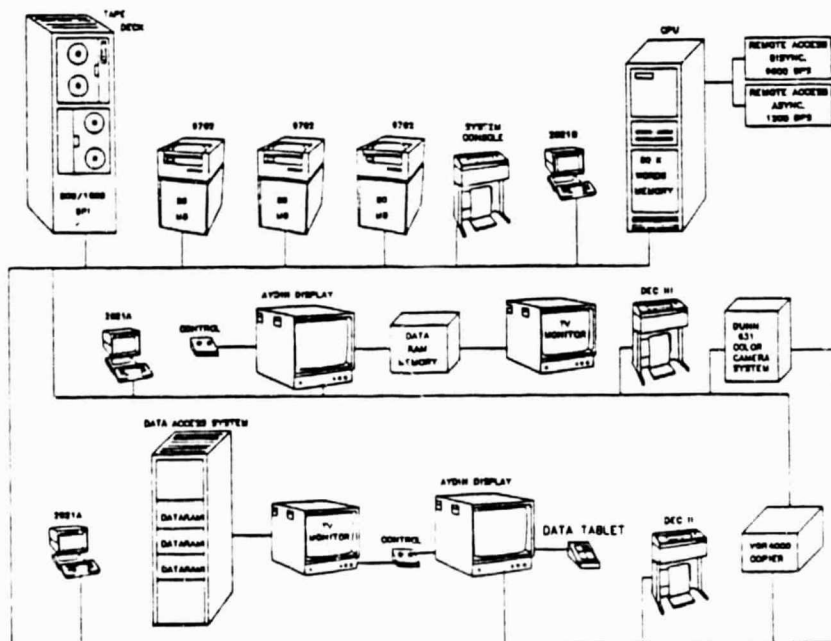
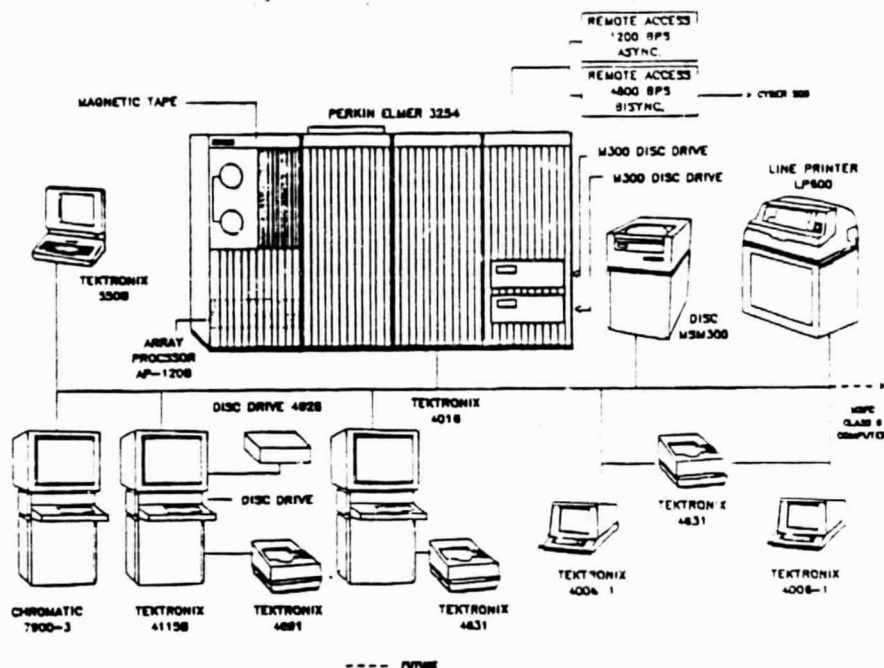


Figure 3-2. Harris/6 Computer System



OCT. 1984

Figure 3-3. Perkin-Elmer Computer System

Remote interactive access to each of the ASD computers is provided by connection to a Develcon terminal switch via four dedicated 1200-baud asynchronous lines using standard RS-232 protocol. The HP-1000F system utilizes two of these lines to provide remote communications and to support both the XON/XOFF and ENQ/ACK protocols. The P-E and Harris/6 utilize the remaining two lines.

The Harris/6 system also has a DDS 9600-baud bisynchronous communication line with the IBM 4381 McIDAS at the University of Wisconsin, which provides access to real-time satellite images and the FAA '604' line data. For real-time support of ASD flight experiments, this line is used to put MSFC directly online as an IBM terminal. More commonly, the line is used as a computer to computer data link to transport 'case study' data sets in a research mode. A special communication software package not only transfers the data, but formats it to be compatible with the SDS, GRID, and IMAGE data structures mentioned above. These digital files, as well as text data, can be transferred in either direction along the IBM 4381-Harris/6 McIDAS communication line.

Various hardcopy devices are available to document the scientist's work, both for general reference or for formal slide or overhead viewer presentations. The screen contents may be copied using either the Dunn Camera (8 x 10 Polaroid print or 35 mm slide) or the relatively inexpensive Honeywell black and white copier.

The Perkin-Elmer system offers an RJE connection via a 4800 baud bisynchronous modem driven by HASP protocol. Scientists currently utilize this link to access NASA's Cyber 205 located at Goddard Space Flight Center for running computer-intensive model code.

4. APPLICATION SOFTWARE

The HP-1000F computer system has a Data Management and Analysis System developed by Atsuko

Computing International (ACI) which has been successfully implemented and utilized daily from the Apple III workstations by atmospheric scientists to graphically display and analyze large volumes of conventional and satellite derived meteorological data. By utilizing a Task Scheduler program, (AVE80), as shown in Figure 4-1, the scientist can process various atmospheric data (sounding, single level grid, and image) interactively. The AVE80 program links approximately 30 software programs, allowing each to share common data and user inputs, thereby reducing overhead, optimizing execution time, and thus enhancing user capabilities. With the AVE80 programs, atmospheric data may be displayed in various forms such as station and parameter base map plots, skew t plots, vertical profiles of selected parameters, displayed images, parameter value printouts, and grid parameter contouring (see Figures 4-2 through 4-5). The user selects the desired data parameters such as data type, set, category, group, and data base. Further, the user must select output type, output device, time period, pressure level, batch or non-batch mode, station number, latitude, longitude, colors, line styles, and several additional options depending on the output desired.

Output devices available to the user include: HP plotters, HP graphics terminals, Apple III monitors, Apple Silentyte printer, and an HP line printer/plotter.

The McIDAS terminals have large capabilities for displaying many types of data from various sources simultaneously. The MSFC researcher typically views a satellite image, with an overlaying graphics plot or contour of some other data type. Based on the combined information, the scientist will select an interesting portion of the image to work on and the procedure to use. Nearly any digitized image can be displayed on McIDAS, including images from most of the meteorological satellites. Since images can be viewed either individually or in animated sequences, a considerable amount of subjective and quantitative information is involved.

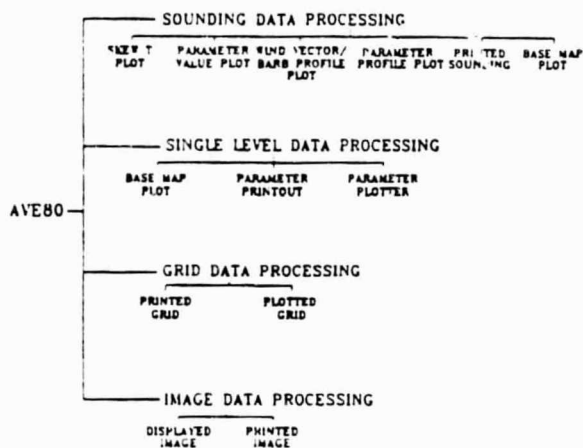


Figure 4-1. AVE80 Data Organization

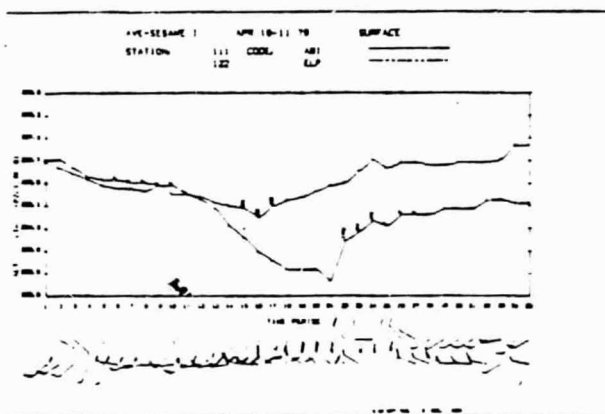


Figure 4-2. Parameter Plotter

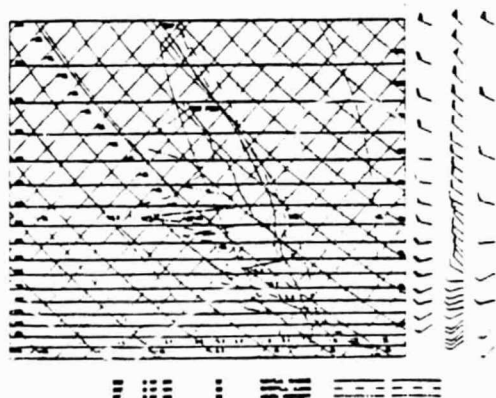


Figure 4-3. Skew t Plot

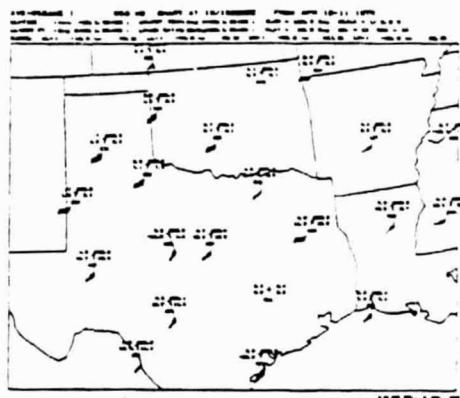


Figure 4-4. Base Map Plot From Sounding Data



Figure 4-5. Printed Image

The user may elect to display any desired meteorological satellite image or a sequence of images for animation purposes. These images can be enhanced in several ways (Figure 2-3b), both in color and black and white. Nearly an infinite selection of colors and combinations can be selected by the user via the keyboard, while the joystick provides a continuous control over brightness, color, intensity, image digital range, and contrast. The same range of colors is available to gradually 'fade' graphics lines. Many different filter functions are available including high and low pass, gradient, edge preserving, and others, with more being added. Other features include stretching and other standard linear functions. Functions of several images can be done, including averaging, maximum and minimum values, and cloud cores. All data on McIDAS can be plotted or contoured, with a large amount of user control over the appearance of resulting plots or contours. The size and colors of labels, and the placement of multiple SDS 'station' parameters surrounding the actual station location are also user controlled.

Several high-level programs exist on McIDAS to permit application of sophisticated algorithms to image data. One such program uses many images at differing spectral wavelengths to reproduce vertical atmospheric temperature and moisture soundings. Another program uses several images in an animated sequence for the purpose of calculating

cloud tracked winds. Calculation of standard statistical parameters and outputs of a histogram on any user selected portion of an image is accomplished by yet another image processing program between any two digital brightness values.

The P-E system currently has several scientific research models operational including WAMPS, Cloud Winds, Pielke's model and the South Dakota 2-D cloud model. NCAR graphics are supported with metacode translators for Tektronix terminals and the FR80 microfiche output. Plans exist to convert the translator to permit color graphics on the Tektronix 4115B.

5. INTERACTIVE SCIENTIFIC DATA PROCESSING (USER INTERFACE)

Four basic types of "user terminals" are integrated into the ASD system to allow the user/scientist to utilize the analysis and display software interactively to generate both color image displays and graphic outputs:

- -- Apple III Workstations
- -- McIDAS
- -- Tektronix
- -- Chromatics

The Apple III workstations may be used as a standalone computer or selectively to access the capabilities of the HP-1000F, Harris/6 McIDAS, or P-E 3250 computers through communication lines. Software has been written which enables the Apple III to be used as an HP terminal including graphics capabilities. Future software will also allow the Apple III workstations to emulate the McIDAS terminal.

Currently, the Apple III terminal "workstations" have been integrated into the ASD computer system with the following capabilities:

- -- Apple III with 256K bytes memory
- -- Apple III Silentype Printer (Graphics Hardcopy)
- -- One of the following Monitors:
 - OMNI Panasonic Monitor TV
 - JVC Color Monitor
 - BARCO Color Monitor
 - High Resolution B&W Monitor
- -- Novation 212A modem or equivalent (9600-baud communication)
- -- 5 MB hard disk

The Apple III terminals were chosen instead of conventional asynchronous terminals due to cost effectiveness, versatility, off-the-shelf availability and graphics and imaging quality.

Each McIDAS 'terminal' consists of the keyboard and CRT echo monitor, the full 'video' display, printer, joysticks, and a data tablet. This complete terminal costs approximately \$200,000. The video display monitor typically stores 16 different image and graphics 'frames', with the capability for expansion by simple addition of a memory board. McIDAS users generally key in their command from a standard keyboard. Joysticks are used for movement of the cursor on the video screen to allow user interaction with the data. Also available is a 'data tablet' and pen which allow the same cursor control and key-in capability with only one hand moving the special pen. All keys are programmable, which permits the user to simply strike the key of his choice to execute one of many commands. Alternatively, several options of a command may be stored, to be combined later with, each option represented by a single keystroke. The McIDAS 'macro' capability allows a sequence of commands to be executed by keying in

only the title of the sequence. The user has basic looping and decision-making capabilities in the execution of a list of commands in a macro. The above capabilities allow the scientists to pre-select a useful subset of McIDAS commands for his research, and simply touch the desired keys. This allows him to observe the results without having to spend valuable time making long key-ins.

The most powerful capability of McIDAS in the research mode lies in its ability to graphically overlay every other data type onto the satellite image projection. In this way, plotted or contoured measurements from the field can be visually related to the satellite images.

A Tektronix 4115B color graphics terminal with dual flexible disk drives, 10 MB Winchester hard disk, and 4691 color hardcopy unit is attached to the P-E for support of NCAR graphics. This terminal is also capable of running in standalone mode under CPM. FORTRAN and the IGL graphics package are also supported.

A Chromatics terminal is also used to produce color graphics output and interactive research on the P-E in support of Doppler Radar/Lidar research activities, specifically using NEXRAD software from NSSL.

6. SUMMARY & CONCLUSIONS

In summary, the ASD Research Computing System currently provides the research scientist with the following capabilities:

- An extensive Data Base Management package to convert various experiment data into standard formats for accessing by the general purpose plotting and data analysis packages.
- An Analysis and Display package (AVE80) to graphically display and analyze large volumes of conventional and satellite derived meteorological data.
- An interactive imaging/color graphics capability utilizing Apple III workstations integrated into the ASD computer system.
- Local and remote smart-terminal capability which provides color video, graphics, and character display of the various data types.
- A high speed minicomputer equipped with array processor for executing compute intensive code.
- Tektronix 4115B and Chromatics graphics terminals for high resolution, high-quality color graphics output.
- Capability to overlay and analyze satellite imagery data and conventional meteorological data. Some image processing capabilities are also available.
- Real-time and archive case study analysis of satellite, imagery and conventional data.

The systems continue to be upgraded to enable them to support future requirements as well as to enhance capabilities of the system to better meet the needs of the scientist/user. For example the P-E is to be upgraded to an MPS system with multiple auxiliary processor units to better accommodate running simultaneous compute-bound jobs. Access to the proposed MSPC Class VI Machine should also provide vast computational improvement by allowing access via Ethernet from each of the machines.